

37. COMMISSION DES AMAS STELLAIRES

PRÉSIDENT: M. W. BAADE, *Mount Wilson and Palomar Observatories, Pasadena 4, Calif., U.S.A.*

MEMBRES: Mme Barkhatova, MM. W. Becker, Binnendijk, Bok, Chandrasekhar, Cuffey Günther, Hertzprung, Mme Sawyer Hogg, MM. Kholopov, Markarian, N. U. Mayall, Mayot, Mineur, Nassau, Rosino, H. Shapley, Trumpler, Vanderlinden Wallenquist, Zagar.

During the last few years the interest of the observers has notably shifted to colour-magnitude diagrams of high precision, both for galactic and globular clusters. The two factors behind this development are, on the theoretical side, increasing interest in the cosmological significance of the two stellar populations; on the practical side, the vast possibilities opened up by the modern photomultiplier cells.

(a) *Galactic Clusters*

Eggen's pioneer work in the field of colour-magnitude diagrams of high precision is well known. During the past two years a lively discussion has been going on as to whether some of the features stressed by Eggen—the fine structure of the colour-magnitude diagram around $M=0$ in the galactic clusters thus far investigated—are significant or not. As a result of this controversy other observers have entered this field and it is to be expected that the debated points will be cleared up before long. Actively engaged in this field are at present—besides Eggen—Harold Weaver (Lick Observatory) who has finished a study of the star cluster in Coma and Harold Johnson (Yerkes and McDonald Observatories) who has published his results for the Pleiades and NGC 2362 and who is working now on Praesepe, M 36, M 39, I.C. 4665, NGC 2244, and other clusters. A most commendable feature of these investigations is the adherence to the international system of magnitudes and colours, thus insuring widest applicability to the results obtained.

(b) *Globular Clusters*

Parallel work on the colour-magnitude diagrams of the globular clusters is now under way at the Mount Wilson and Palomar Observatories. Since the photocell is not suitable to handle the large numbers of stars in rich globular clusters, the determination of photographic and photovisual magnitudes is carried out photographically at the large reflectors. But in each cluster the basic sequence of magnitudes and colours is established photo-electrically by intercomparisons with the Pole and nearby standard areas. Thus the photographic plate merely serves as a convenient auxiliary to interpolate large numbers of stars into a given sequence of high precision. At present three globular clusters are under investigation: Messier 3 by Sandage; Messier 13 by Baade and Savedoff; and Messier 92 by Arp and Sandage. The photo-electric sequences in these clusters are established by W. A. Baum at the 200-inch. Colour-magnitude diagrams extending to $m=21$ should be available for the three clusters before the end of 1952. The colour-magnitude diagram of the southern globular cluster NGC 6397, based on plates taken with the 26-inch Yale refractor, has been investigated by Miss Henrietta Swope at the Rutherford Observatory, the limiting magnitude being $M=+2.5$.

WALTER BAADE
President of the Commission

According to instructions of the Astronomical Council of the Academy of Sciences of the U.S.S.R., I am hereby presenting you a brief summary of results of the work on star clusters published in U.S.S.R. after the VIIth Congress of the International Astronomical Union.

1. B. E. Markaryan conducted at the Burakan Astrophysical Observatory a research on the structural peculiarities of those galactic clusters, the hottest stars of which belong

to the interval of spectral types O-B2. It was found that in all cases a cluster contained at least one system belonging to one of the following types: (i) Multiple systems of the type of the Trapezium of Orion, and (ii) star chains.

By a multiple system of the type of the Trapezium of Orion has to be understood such a multiple star in which at least three components may be selected, all the three distances between them being of the same order (the majority of the ordinary multiple stars, as we know, do not possess such property).

Examples of clusters containing multiple systems of the type of the Trapezium are the following: IC 4996 (multiple stars ADS 13626), IC 1848 (multiple stars ADS 2161 and ADS 2165), χ Persei and the cluster which surrounds the Trapezium of Orion.

An example of a cluster containing chains of stars is the NGC 7510.

In all cases, the chief components of the multiple systems of the Trapezium type and of the star chains are among the brightest stars of the cluster.

Galactic clusters connected with gas nebulae ordinarily contain one system each of the Trapezium type.

The results of a study of the structural peculiarities of the open clusters, which contain stars of the O-B2 interval, made it possible for Markaryan to outline the main features of a new classification of these clusters (*Burakan Publ.* No 5, 1950).

The same author published in 1951 a list of fifty galactic clusters which according to his classification belong to type O. The hottest stars in these clusters are of the spectral types O to BO. For each cluster are given the structural characteristics (the presence of a multiple system of the type of the Trapezium in Orion, of a stellar chain, connection with gaseous nebulosities). The structural peculiarities were obtained from photographs taken at the Burakan Observatory, the spectral types of the cluster members from publications of other observatories (*Communications Burakan Observatory*, No. 9, 1951).

2. V A. Ambartsumian showed (*A.J. U.S.S.R.* **26**, 1, 1949) that many galactic clusters containing stars of the spectral interval O-B2 are surrounded by very extended and rarified groups of hot stars. These groups of stars, which have received the name of O-associations, have, in certain cases, diameters up to 100 parsec. and more. Star clusters play the role of nuclei of the corresponding associations. Certain O-associations have two and more nuclei. Examples are the well-known groups of O and B stars in Perseus and Cygnus. The former has two nuclei, the latter contains four or five nuclei (open clusters).

It should be pointed out that clusters which are nuclei of O-associations ordinarily contain multiple systems of the type of the Trapezium of Orion, or star chains.

However, isolated multiple systems of the Trapezium type, and star chains not entering the clusters, are also met in associations.

Ambartsumian directed his attention to the dynamic instability of the O-associations.

Rarified systems which have received the name of T-associations, consisting of variable stars of the T Tauri (RW Aurigae) type, must possess the same instability. From this, Ambartsumian concluded that both the O-associations and the T-associations are extremely young formations (their age does not exceed twenty or thirty million years).

Formations of particularly young age must be the multiple systems of the Trapezium type and star chains which are a part of the O-associations. Dynamic considerations show that their age does not exceed several millions of years (*Burakan Publ.* No. 2, 1949).

3. P N. Kholopov (Astronomical Council) demonstrated that the well-known stars of the T Tauri type form more than ten T-associations. Their distances from us do not exceed several hundred parsec. In view of the low luminosity of the stars of T-associations, we do not observe more distant T-associations.

The same author has published a paper on the association of hot giants around the galactic cluster NGC 6231 in Scorpio (*A.J. U.S.S.R.* **28**, 1951).

4. P P Parenago (Sternberg Astronomical Institute) made a detailed investigation of the system of variable stars of the T Tauri type connected with the Orion Nebula (*Var. St.* **7**, no. 4, 1950). In the centre of this system is the Trapezium of Orion. This

system is the richest of the known T-associations. On the other hand, in view of the fact that the Trapezium of Orion is a part of the O-association in Orion, we may conclude that in this case we have a complex association of the type of O+T. Parenago advanced a number of arguments in favour of the fact that the variability of stars in the Orion Nebula cannot be caused by their being screened by the nebula, as it has hitherto been considered by a number of authors.

5. P. P. Parenago, B. V. Kukarkin and N. F. Florya (*Stern. Astr. Inst. Publ.* **16**, 47, 1949) have investigated the system of globular clusters. It has been demonstrated that the apparent diameters of the globular clusters depend upon the absorption of light.

6. K. A. Barkhatova (*A.J. U.S.S.R.* **26**, nos. 4 and 6, 1949; **27**, no. 3, 1950) has shown that the apparent diameters of open star clusters are subject to the influence of the absorption of light. This explains why Trümpler obtained a reduced value for the coefficient of the general absorption of light in the Galaxy. Barkhatova investigated the spatial distribution of open clusters, and also demonstrated that the anomalously small values of the Oort constant 'A', obtained by H. Mineur, are explained by an insufficient account of the light absorption. Barkhatova made a proper account of the absorption, and obtained a normal value of A in the clusters (19.9 ± 1.4 km./sec.).

7. A. G. Masevich has analysed the spectrum-luminosity diagrams of a series of open clusters. Considerations based on the internal structure of the stars led to the conclusion that the chemical composition of the stars of each cluster, at the time of its formation, was approximately the same but different for different clusters (*A.J. U.S.S.R.* **28**, 238, 1951).

V A. AMBARTSUMIAN

Herr W. Becker hat auf Grund von Erfahrungen, die er bei seiner 3 Farben-Photometrie offener Sternhaufen mit dem 60 cm.-Spiegel sammelte, eine Methode zur gleichzeitigen Bestimmung des Entfernungsmoduls und der Verfärbung von offenen Sternhaufen entwickelt, die keine Kenntnis der Spektral-typen benötigt. Aus Helligkeiten in den drei Bereichen 370 , 470 und 630μ kann bei Wasserstoffsternen ein Mass der Balmerabsorption, bei späteren Spektraltypen ein Mass der kurzwelligen Depression hergeleitet werden. Beide Zahlen sind deutlich mit der absoluten Helligkeit der Hauptsterne gekoppelt, zu deren Bestimmung also der Spektraltypus überflüssig ist. Der Methode sind auch lichtschwache und konzentrierte offene Haufen zugänglich. Ich selbst habe seit längerer Zeit eine photographische Photometrie der Hyaden in Arbeit, die aber infolge ihres grossen Areals einer Präzisionsphotometrie Schwierigkeiten bereitet. Ich hoffe, sie 1951 abschliessen zu können. Herr Stock hat mittels eines neuartigen von Herrn Wellmann berechneten Triplets eine 3 Farben-Photometrie der Coma Berenices durchgeführt.

O. HECKMANN

Hamburger Sternwarte, Bergedorf

Stationäre und instationäre Modelle von Sternsystemen wurden konstruiert und versuchsweise auf reale Sternsysteme angewendet. Ein stationäres kugelsymmetrisches Modell mit ellipsoidischer Geschwindigkeitsfläche (eine Verallgemeinerung eines Ansatzes von Eddington und Jeans) erlaubte die Abschätzung der Masse einiger Kugelsternhaufen auf durchschnittlich eine Million Sonnenmassen. Dabei wurden die von Joy gemessenen Radialgeschwindigkeiten von veränderlichen Sternen in Kugelhaufen benutzt. Der Virialsatz lieferte (ohne die Einschränkung auf Stationarität) dieselbe Grössenordnung. Die nähere Untersuchung zweier instationärer Modelle nach der Theorie von Chandrasekhar und Schürer zeigte die Unvereinbarkeit mit der Poissonschen Gleichung. Daher wurde ein neuer, möglichst allgemeiner Ansatz versucht: eine Methode, die bei beliebiger Anfangsverteilung ermöglicht, näherungsweise die Entwicklung des Sternsystems während beschränkter Zeitdauer zu verfolgen. Damit soll der Schwerpunkt des Problems von der mathematischen Analyse auf die Aufstellung und Diskussion der Anfangsverteilung verlegt werden. Bisher wurde die Entwicklung einer

anfänglich nahezu homogenen kugelsymmetrischen Sternansammlung untersucht und zur Deutung der Kugelsternhaufen herangezogen. Eine Erweiterung auf rotierende Systeme ist in Arbeit. Die Arbeiten wurden veröffentlicht in der *Z. f. Aph.*

M. SCHÜRER
Universität Bern, Astronomisches Institut

You already know much of our cluster activities during the past triennium. In summary, they are: (1) Three-colour photo-electric photometry at our Oak Ridge Station on the Pleiades, and possibly on other clusters by M. K. Vainu Bappu. (2) Continuing study of the distribution of the apparent magnitudes of stars in three of the brightest southern globular clusters (general luminosity curves). (3) Futile attempt to find cluster type Cepheids in the allegedly globular clusters of the Magellanic Clouds. (4) The finding of typical Cepheid variables in a cluster (NGC 1866) in the Large Magellanic Cloud, thus indicating its uniqueness, whether considered a globular cluster or an open cluster. (5) The determination of the photo-electric colour-magnitude array for the southern galactic cluster NGC 2477 by Mr Uco van Wijk at the Boyden Station: (6) Development by Ivan King (Harvard Junior Fellow) of a method for determining the stellar density in globular clusters.

HARLOW SHAPLEY
Harvard College Observatory

Report of the meeting

PRESIDENT: Dr W. BAADE.

SECRETARY: Prof. H. L. VANDERLINDEN.

The report of the Commission was adopted.

The Chairman then pointed out that with the arrival of the photo-multiplier cell a new field of research had been opened up for investigating both galactic and globular clusters, and that great progress had to be expected during the next few years in the investigation of precise colour-magnitude diagrams of clusters. The pioneer work on this field was done by Eggen, but doubts had arisen about the detail sequences in some of the galactic clusters observed by him. In this connexion Dr G. Miczaika, and Dr H. F. Weaver reported about their photo-electric observations of the Coma cluster of stars, the colour-magnitude diagram of which had been earlier observed by Eggen. Neither Miczaika nor Weaver had been able to find Eggen's fine structure in the colour-magnitude diagram in the range of the A-stars. Miczaika's results are summarized in his note at the end of this report.

Prof. O. Heckmann then reported about a new colour-magnitude diagram of the Hyades obtained by photographic photometry at Bergedorf. The precision of the new data is about the same as that of Eggen. Heckmann also failed to verify the sequences of Eggen in the range of the A and the F stars. The Bergedorf list contains twice as many members as Eggen's list on the same field. The individual parallaxes of all members were derived from new proper motions based on a combination of plates of the *Astrographic Catalogue* with new plates taken with the AS-Astrograph. Heckmann suspects a certain fraction of stars in the Hyades as well as in Praesepe to be variable to an amount of some hundredths of a magnitude.

Dr Stoy expressed the wish that the photo-electric observers of galactic clusters include in their measures magnitudes and colours of a few field stars in the neighbourhood of the clusters, which would be valuable for other photometric observers as sequences. The additional work involved would be small.

Prof. V. Ambartsumian then presented a photographic atlas of open clusters recently published by Markarjan of the Burakan Observatory in Armenia (U.S.S.R.). The chief purpose of this atlas is to illustrate the classification of the open clusters as developed at the Burakan Observatory in the course of the work on stellar associations. The

photographs in the atlas show the structural properties of clusters of different types. Special attention is given to the clusters which are connected with O-associations. The Chairman adds that the new Burakan atlas undoubtedly will be welcomed by all investigators interested in galactic clusters and it should provide a most valuable aid to all observers planning programmes in this field. In answer to a question how the atlas can be obtained, Prof. Ambartsumian stated that in view of the high cost of reproduction the atlas cannot be distributed individually, but that all observatories will be provided with copies.

Finally Dr A. D. Thackeray of the Radcliffe Observatory brought up the question of the classification of the so-called globular clusters in the large Magellanic Cloud.

His earlier work on NGC 1866 had shown that this cluster, the brightest in the LMC and up to then considered globular, had, contrary to the globular clusters of our own galaxy, not a colour-magnitude diagram of the stellar population II (the brightest stars in this cluster turned out to be blue and not red stars as in the globular clusters of our galaxy).

Continued investigations at Pretoria strongly suggest that there are two types of 'globular' clusters in the LMC, one in which the brightest stars are red, the other in which they are blue. In the discussion the chairman pointed out that Kron and Gascoigne in a recent paper in *A.S.P.* find a similar division of the clusters of the LMC in two groups from photo-electric measures of their integrated colours. The two groups seem to be quite distinct, one centering around a colour index slightly larger than zero, the other around a colour index of about $+0^m.6$. In agreement with Thackeray's findings NGC 1866 belongs to the blue group. In view of this situation it would be highly desirable to obtain colour-magnitude diagrams of one or two of the brightest clusters in each group. Obviously the situation in the LMC is quite different from that in our galaxy. Whereas in our own galaxy globular clusters occur only in the population II, they occur in the LMC both in populations I and II. Since the term 'globular' is simply a loose term to designate an exceedingly rich cluster all confusion would be avoided if we divided the star clusters according to their colour-magnitude diagrams in clusters of the population types I and II, each group containing clusters ranging from very poor ones of a loose character to exceedingly rich ones of the globular sort.

In our own galaxy, only the population II contains rich clusters which deserve the designation 'globular', whereas in the LMC 'globular' clusters occur in both populations.

Farben-Helligkeits-Diagramm des Sternhaufens in Coma Berenices

Zusammen mit Herrn K. Bahner wurden lichtelektrisch (Elektronenvervielfacher 1 P 21 und 32 cm.-Refraktor) Farbenindices und Helligkeiten von 39 Mitgliedern des offenen Haufens in Coma Berenices gemessen, die ein neues Farben-Helligkeitsdiagramm ergeben. Die Mehrzahl der Sterne liegt entlang einer als Hauptreihe anzusehenden Sequenz. Die wenigen etwas herausfallenden Sterne sind bekannte Doppelsterne oder können fast alle zwanglos als nicht erkannte Duplices betrachtet werden. Die Sequenzen von Eggen lassen sich im Diagramm nicht verifizieren.

Die erzielte Genauigkeit einer Einzelmessung der Farbenindices und Helligkeiten beträgt $\pm 0^m.011$ (m.F.). Die m.F. der Katalogwerte liegen im Durchschnitt bei $\pm 0^m.005$ für die Farbenindices und $\pm 0^m.007$ für die Helligkeiten.

G. R. MICZAIKA